no action req

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: June 1, 1976

Project Title: Electromagnetic Survey in Louisville, Kentucky

Project No: A-1845

Project Director: Mr. B. M. Jenkins

Sponsor: South Central Bell Telephone Company; Louisville, Kentucky 40202

Agreement Period: From June 1, 1976 Until August 1, 1976 (Agree. Period)

Type Agreement: Letter Agreement dated 3/23/76

Amount: $5,250 (Fixed-Price)

Reports Required: Survey Results

Sponsor Contact Person (s):

Technical Matters

Mr. R. S. Shifley
State Building Engineer
South Central Bell-Telephone Company
1800 Citizens Plaza
Louisville, Kentucky 40202

Contractual Matters
(thru OCA)

Same as technical

Defense Priority Rating: None

Assigned to: Electronic Technology (~~School~~/Laboratory)

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- Other

CA-3 (3/76)

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SPONSORED PROJECT TERMINATION

Date: 11/12/76

Project Title: Electromagnetic Survey in Louisville, Kentucky

Project No: A-1845

Project Director: Mr. B. M. Jenkins

Sponsor: South Central Bell Telephone Company, Louisville, Kentucky 40202

Effective Termination Date: July 30, 1976

Clearance of Accounting Charges: Fixed Price Contract

Grant/Contract Closeout Actions Remaining:

- x Final Invoice and Closing Documents
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
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- _ Other ______

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CA-4 (3/76)

A#10

ELECTROMAGNETIC SURVEY IN

LOUISVILLE, KENTUCKY

By

B. M. Jenkins and R. S. Smith

July 1976

Submitted To

SOUTH CENTRAL BELL TELEPHONE COMPANY
1800 Citizens Plaza
Louisville, Kentucky 40202

Prepared By

Electronics Technology Laboratory
ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
Atlanta, Georgia 30332

FOREWORD

This report was prepared by the Electronics Technology Laboratory of the Engineering Experiment Station at the Georgia Institute of Technology. The work was performed in accordance with a letter proposal/ agreement (Proposal No. ET-EMC-76-07) with South Central Bell Telephone Company, dated March 23, 1976. The described work was conducted under the general supervision of Mr. D. W. Robertson, Director, Electronics Technology Laboratory, and Mr. B. M. Jenkins, Project Director. This report summarizes the objective, activities, and results of a program concerned with measuring the radiated electromagnetic environment at a proposed Data Center site in Louisville, Kentucky.

The authors gratefully acknowledge the assistance provided by Mr. R. S. Webster, and Mr. S. M. Blust of South Central Bell Telephone Company, Louisville, Kentucky.

ABSTRACT

Investigations were performed to define the electromagnetic environment at the site proposed for a South Central Bell Telephone Data Center in Louisville, Kentucky. The purpose of this report is to describe the investigations that were conducted and the results obtained. The approach established for performing the investigations is presented, along with a detailed description of the test equipment, techniques, and procedures which were employed. Test results are presented which describe the radiated environment at the site as a function of frequency, amplitude, and test location.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. Introduction

During the past few decades, utilization of the electromagnetic spectrum has undergone an unprecedented growth. The areas within which this growth has occurred literally run the gamut from electronic toys for children to highly sophisticated communication and radar systems for national defense. Generally, utilization of the spectrum for these purposes is desirable, and in cases such as national defense, probably mandatory. As might be expected, however, this rapid increase in spectrum utilization has not been without certain problems. Many of these problems are discussed in terms of electromagnetic interference* considerations. They commonly manifest themselves as electromagnetic nuisances[1] such as congested communication channels and signal cross-talk between adjacent cables; however, electromagnetic interference is also capable of causing equipment malfunctions[2] that may jeopardize human life.

One of the areas within which electromagnetic interference is receiving increasing attention is concerned with electronic equipment susceptibility or vulnerability. This attention is being directed to the fact that major electronic equipments have been shown to be incapable of functioning properly during exposure to ambient electromagnetic environments. As a result, it has become necessary in many instances to design facilities which house these equipments in such a manner that electromagnetic environments are reduced to tolerable levels.

The technical efforts undertaken on this project were directed to determining the magnitude of the electromagnetic environment at a site proposed for a telephone data center. This magnitude was of concern because of the suspect nature of electronic equipments to be used for data processing. Of particular concern were discrete frequency signals being transmitted by local AM and FM broadcast stations, VHF and UHF television stations, weather radar systems, etc.

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*Electromagnetic interference is generally defined as either malfunctioning of or performance degradation in electronic devices caused by undesired signals transmitted through space or conducted along wires. The undesired signals may occupy either narrow or broad portions of the frequency spectrum.

Subsequent portions of this report identify the site location, describe the test procedures and equipments used, and present the field intensity magnitude measured.

2. Site Location

The location at which these field intensity mappings were made was a proposed construction site for a South Central Bell Telephone Company Headquarters Building in Louisville, Kentucky. The site was in the northwest section of downtown Louisville, and was bounded on three sides by Sixth, Seventh, and Chestnut Streets, as shown in Figure 1. Field intensity mappings were made at two different locations on the site. These locations and their approximate position relative to each other and to the streets are indicated on Figure 1.

3. Measurement Instrumentation and Procedures

The measurements of field intensity at the proposed site were made on June 7, 8, and 9, 1976. Two different measurement approaches were used for these field intensity mappings: (1) signal levels at discrete frequencies corresponding to known local transmitters were measured, and (2) a frequency scan from 500 kHz to 10 GHz was made to determine whether other signals of appreciable magnitude existed. During every mapping, the antenna height above ground was 15 feet. Weather conditions on all three days were clear with an approximate temperature of 80 degrees Fahrenheit.

During all efforts to determine the field intensity at the proposed site, operating procedures and calibration factors provided for the test equipment by the manufacturer were used. As a verification that the recorded field magnitudes were accurate, a known electromagnetic environment was generated in a shielded enclosure[3] and the equipment was used to map the resulting field intensities. The measured intensities completely qualified both the operating procedures and calibration factors provided by the manufacturer, thereby providing assurance that field intensities measured at the proposed site were correct.

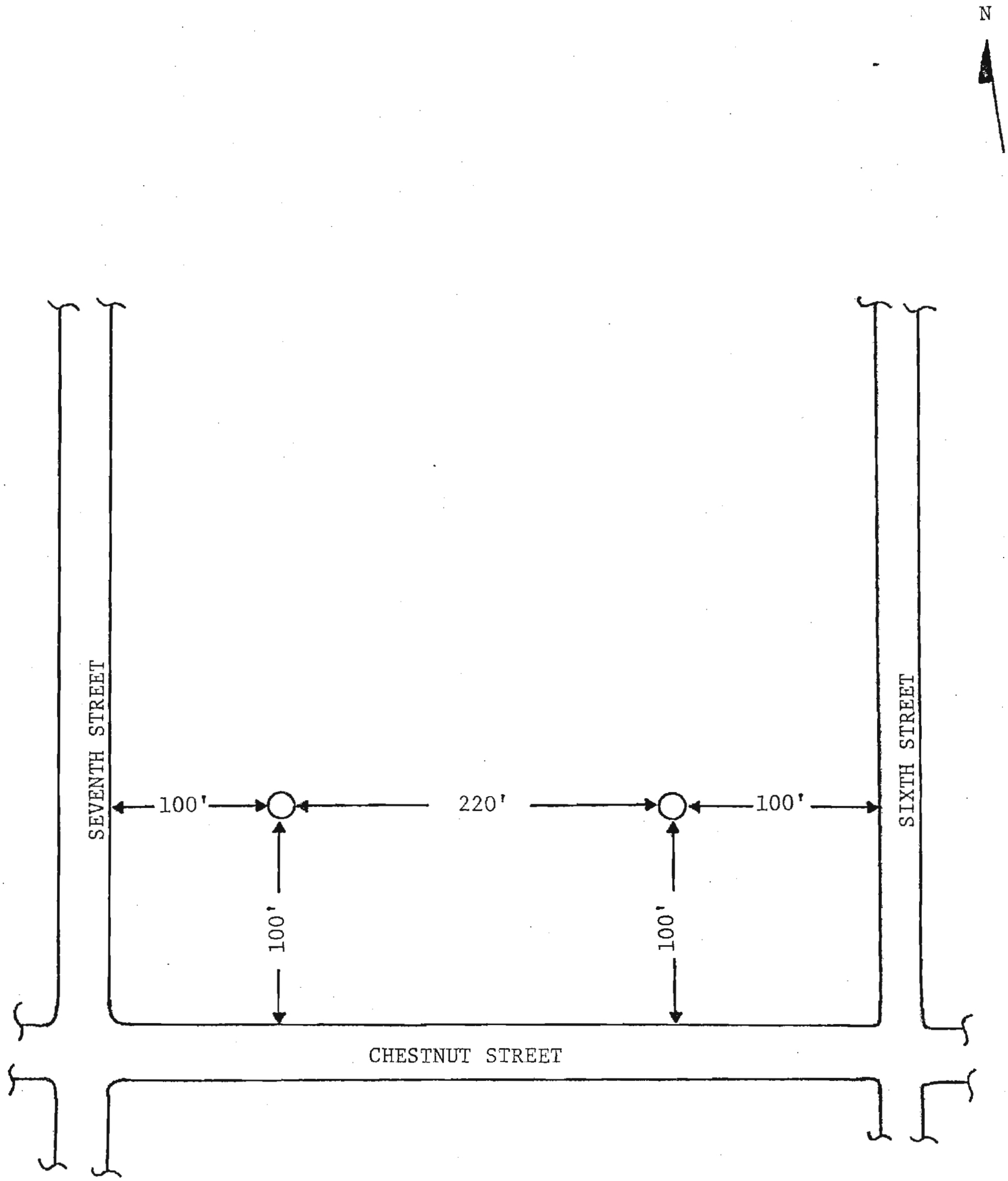


Figure 1. Test Site with Approximate Measurement Locations.

Specific measurement instrumentation and procedures used in conducting the field intensity mappings are presented in the following paragraphs.

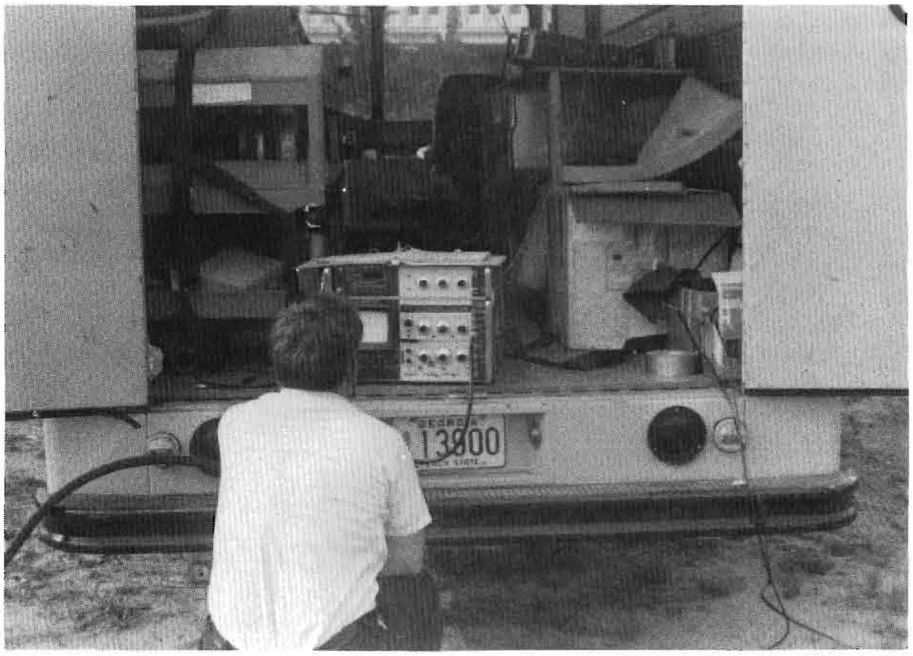
3.1 Measurement Instrumentation

Because of its versatility, portability, wide frequency range and availability of a visual display, a spectrum analyzer was chosen as the basic receiver for conducting the field intensity measurements. The actual spectrum analyzer used was a Hewlett-Packard 8550 System with a Model 141T Display Unit and a Model 8552 IF Section. Various Hewlett-Packard RF plug-in units were used, depending on the frequency range of interest. During the tests this spectrum analyzer was used with a complement of five different antenna types to cover the frequency range of 500 kHz to 10 GHz. A Hewlett-Packard Model 8640B Signal Generator and a Model 5245L Frequency Counter were used as a means of calibrating spectrum analyzer frequency bands.

Photographs showing the arrangement of the test instrumentation are presented in Figure 2. Linearly polarized antennas were rotated in azimuth for maximum signal indication in both vertical and horizontal polarizations. Circularly polarized antennas were rotated in azimuth until maximum signal levels were indicated on the analyzer display. The 500 kHz to 10 GHz radiated test frequency range was subdivided into thirteen individual bands in order to accommodate the complement of antennas and to provide the necessary degree of frequency resolution on the display. These bands, the antennas used for each band, and the applicable analyzer RF unit are shown in Table I.

3.2 Measurement Procedures

To perform the measurements, the spectrum analyzer, the ancillary test equipment, and the applicable test antenna were interconnected as shown in Figure 3. The test antenna was initially disconnected to permit amplitude calibration of the spectrum analyzer. The antenna was then reconnected to the analyzer, and a measurement band consistent with the frequency range of the test antenna was selected. The antenna was then rotated in both azimuth and elevation



(a) TEST EQUIPMENT

(b) ANTENNA AND VAN

Figure 2. Test Configuration for Field Intensity Mapping.

TABLE I

RADIATED MEASUREMENT TEST EQUIPMENT AS A FUNCTION OF FREQUENCY BAND

Frequency Range (MHz)	Test Equipment: Antennas	Test Equipment: Spectrum Analyzer* RF Unit
0.35→0.85	Singer LP-105 Loop	HP-8553
0.5→2.5	Singer LP-105 Loop	HP-8553
1.0→6.5	Singer LP-105 Loop	HP-8553
4.0→14.0	Singer LP-105 Loop	HP-8553
12.0→32.0	Singer LP-105 Loop	HP-8553
20.0→220.0	BIA-25 Biconical	HP-8554L
200.0→700.0	LCA-25 Log Conical	HP-8554L
700,0→1200.0	LCA-25 Log Conical	HP-8554L
1000.0→2000.0	ASN-113A Log Spiral	HP-8555A
2000.0→4000.0	Narda 643 Horn	HP-8555A
4000.0→6000.0	Narda 642 Horn	HP-8555A
6000.0→8000.0	Narda 641 Horn	HP-8555A
8000.0→10000.0	Narda 640 Horn	HP-8555A

*Display unit 141T and IF section 8552 used for all Bands.

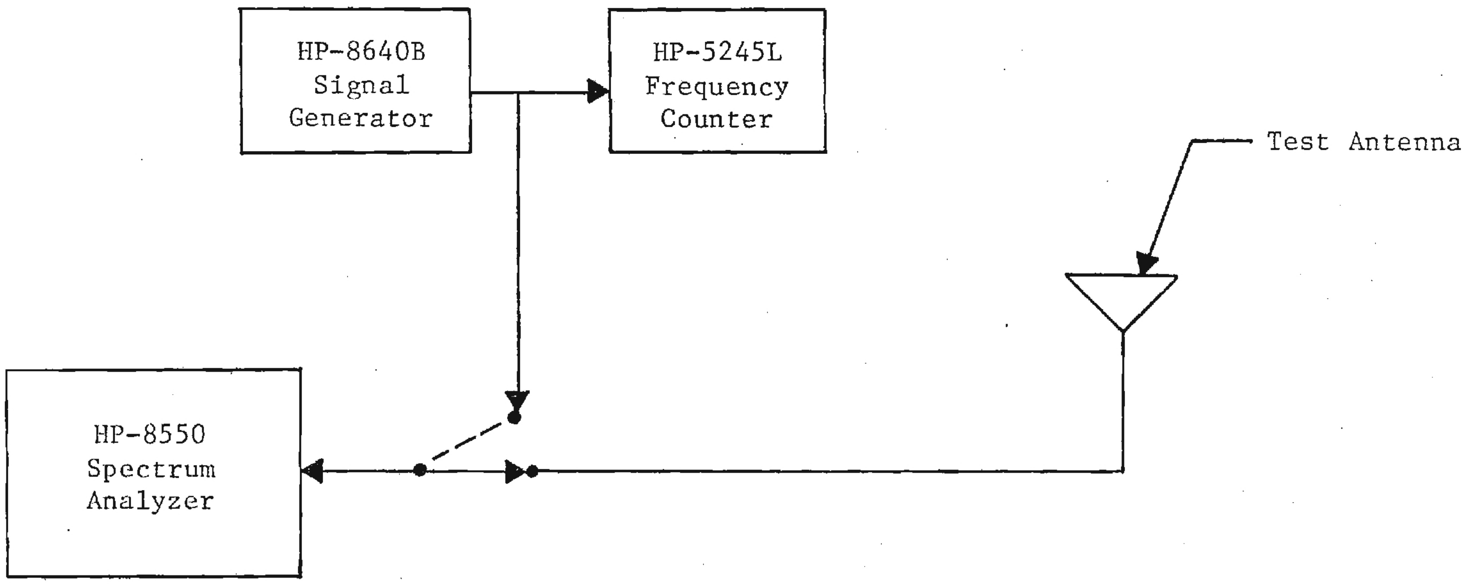


Figure 3. Block Diagram of Test Configuration for Field Intensity Measurements.

positions until the direction yielding maximum signal level and optimum polarization was established. The maximum magnitude of each of the discrete signals was determined from the test instrument display and used in conjunction with known antenna characteristics to provide field intensity in units of volts per meter. After each measurement, the signal generator and counter were used to precisely identify the frequency of the measured signal.

4. Measurement Results

Field intensity magnitudes are commonly measured in units of volts per meter while susceptibility limits for electronic devices are typically specified in units of decibels above one microvolt per meter, consequently, field intensities measured at the proposed site are presented in both units for convenience. Further, conversions between the two units are provided in Table II as an aid in efforts to determine the need for shielding in any facility that may be constructed on the proposed site.

Field intensity mappings were made during the first day of testing at location #1 on Figure 1. Subsequent mappings on the following two days were made at test location #2. These mappings involved the use of the spectrum analyzer and associated antennas to measure all rf transmissions of significant magnitudes (greater than one millivolt per meter) in the specified frequency range. Resulting field intensity magnitudes are presented in Tables III through VII. To facilitate interpretation, this data is categorized into the following functional frequency bands:

- AM Broadcast
- FM Broadcast
- TV Broadcast
- South Central Bell Microwave Radio
- Miscellaneous

The miscellaneous category includes mobile radio communication frequencies, VHF and radar weather frequencies, and frequencies of unknown origin

TABLE II

CONVERSION TABLE

Volts/Meter	dB/μV/m	Volts/Meter	dB/μV/m
3.160	130	0.178	105
2.820	129	0.159	104
2.510	128	0.141	103
2.240	127	0.126	102
1.995	126	0.112	101
1.778	125	0.100	100
1.585	124	0.089	99
1.413	123	0.079	98
1.259	122	0.070	97
1.122	121	0.063	96
1.000	120	0.056	95
0.891	119	0.050	94
0.794	118	0.044	93
0.708	117	0.039	92
0.631	116	0.035	91
0.562	115	0.031	90
0.501	114	0.028	89
0.447	113	0.025	88
0.398	112	0.022	87
0.355	111	0.020	86
0.316	110	0.017	85
0.282	109	0.015	84
0.251	108	0.014	83
0.224	107	0.012	82
0.200	106	0.011	81

TABLE III

FIELD INTENSITY AT PROPOSED SITE -- AM COMMERCIAL BROADCAST STATIONS

		Measured RF Field Intensity			
		Location #1		Location #2	
Station	Frequency (MHz)	Volts/Meter	dBμV/m	Volts/Meter	dBμV/m
WTMT	0.620	0.044	93	0.044	93
WAKY	0.790	0.039	92	0.035	91
WHAS	0.840	0.039	92	0.044	93
WFIA	0.900	0.056	95	0.050	94
WAVE	9.070	0.141	103	0.112	101
WKLO	1.080	0.251	108	0.126	102
WINN	1.240	0.031	90	0.031	90
WREY	1.290	0.009	79	0.011	81
WLOU	1.350	0.178	105	0.178	105
WXVW	1.450	0.044	93	0.044	93
WHEL	1.570	0.017	85	0.020	86

TABLE IV

FIELD INTENSITY AT PROPOSED SITE -- FM COMMERCIAL BROADCAST STATIONS

		Measured RF Field Intensity			
		Location #1		Location #2	
Station	Frequency (MHz)	Volts/Meter	dBμV/m	Volts/Meter	dBμV/m
WFPL[1]	89.3	0.112	101	0.159	104
WFPK[1]	91.9	0.355	111	0.316	110
WQHI	95.7	0.035	91	0.035	91
WNNS	97.5	0.010	80	0.025	88
WCSN	99.7	0.020	86	0.022	87
WLRS	102.3	0.501	114	0.447	113
WSTM	103.1	0.0009	59	0.0014	63
WFIA	103.9	0.178	105	0.447	113
WVEZ	107	0.025	88	0.020	86

Note: FM Stations WFPL and WFPK have applications in to the FCC which would allow them to increase their ERP to 100 kW. If this occurs, the respective rf signal levels at the site will increase approximately 20 dB at 89.3 MHz (WFPL) and 7 dB at 91.9 MHz (WFPK).

TABLE V

FIELD INTENSITY AT PROPOSED SITE -- TV COMMERCIAL BROADCAST STATIONS

			Measured RF Field Intensity			
			Location #1		Location #2	
Channel	Function	Frequency (MHz)	Volts/Meter	dBµV/m	Volts/Meter	dBµV/m
3/WAVE	Video	61.25	0.015	84	0.028	89
	Audio	65.75	0.010	80	0.014	83
11/WHAS	Video	199.25	0.112	101	0.050	94
	Audio	203.75	0.044	93	0.017	85
15/WKPC	Video	477.25	0.159	104	0.141	103
	Audio	481.75	0.089	99	0.063	96
32/WLKY	Video	579.25	0.355	111	0.398	112
	Audio	583.75	0.112	101	0.159	104
41/WDRB	Video	633.25	0.447	113	0.200	106
	Audio	637.75	0.112	101	0.100	100
68/WKMJ	Video	795.25	*	*	*	*
	Audio	799.75	*	*	*	*

*Channel 68 (WKMJ) was not transmitting during the electromagnetic survey.

TABLE VI

FIELD INTENSITY AT PROPOSED SITE -- SOUTH CENTRAL BELL MICROWAVE RADIO SYSTEM

	Measured RF Field Intensity			
	Location #1		Location #2	
Frequency (MHz)	Volts/Meter	dBμV/m	Volts/Meter	dBμV/m
3725	0.007	77	0.0056	75
3740	0.0056	75	0.014	83
3795	0.022	87	0.0089	79
3810	0.014	83	0.005	74
3840	0.007	77	*	*
3880	0.017	85	*	*
3905	*	*	0.012	82
3950	0.031	90	0.0035	71
4040	0.022	87	0.005	74
4110	0.017	85	0.0079	78

*Signal not detected at this location.

TABLE VII

FIELD INTENSITY AT PROPOSED SITE -- MISCELLANEOUS TRANSMISSIONS

		Measured RF Field Intensity			
		Location #1		Location #2	
Identification	Frequency (MHz)	Volts/Meter	dBµV/m	Volts/Meter	dBµV/m
Weather Services					
° VHF	162.47	0.02	86	0.0028	69
° Radar					
CHN. 3	5400	0.398	112	0.089	99
CHN. 32	5400	*	*	*	*
Land Mobile Services	152.23	0.05	94	0.200	106
	152.48	0.159	104	*	*
	152.51	0.141	103	0.07	97
	152.63	0.200	106	0.159	104
	152.75	0.141	103	*	*
	152.78	0.200	106	0.141	103
	156.80	*	*	0.05	94
	158.90	0.022	87	0.079	98
Unknown	27.5	*	*	0.0017	65
	31.5	*	*	0.031	90
	34.6	0.0004	53	*	*
	36.0	0.031	90	*	*
	37.0	0.0044	73	0.0014	63
	43.0	0.0003	48	*	*
	44.0	0.0003	48	*	*
	45.0	0.063	96	0.056	95
	48.3	0.0004	52	*	*

*Signal not detected at this location.

As the test results indicate, the most intense AM broadcast signal was 251 millivolts per meter. This signal intensity was measured at 1080 kHz, corresponding to Station WKLO. The most intense FM broadcast signal occurred at 102.3 MHZ (WLRS) and had a magnitude of 501 millivolts per meter. An intense signal from this station was expected since it was located approximately one mile from the proposed site. Regarding television stations, the most intense signal measured was at 633.25 MHz which corresponds to the video signal of Channel 41. The magnitude of this signal was 447 millivolts per meter.

As for signal contributions provided by the South Central Bell Microwave Radio System, a 31 millivolt per meter level at 3950 MHz was the most intense. This condition was not unexpected since microwave transmissions of this type are normally highly directive. Consequently, if the survey antennas were not directly in the main beam of the microwave transmission, little if any signal would be measured.

For the miscellaneous transmissions, the Channel 3 weather radar transmission at 5400 MHz was the most intense signal, having a level of 398 millivolts per meter. This level was measured at test location #1 while the radar was operated per our request at its minimum "look angle" which should represent "worse-case" conditions. In contrast, the measurement at test location #2 was made with the radar operating at a normal "look angle" and the level was only 89 millivolts per meter. Of the remaining miscellaneous transmissions, only the land mobile communication signals were greater than 100 millivolts per meter. The maximum of these signals was 200 millivolts per meter, occurring at 152.63 and 152.8 MHz.

5. Conclusions

Based on these results, the following conclusions can be drawn:

(a) If the proposed site is selected as the location for the Headquarters Building, electronic equipments located within the facility at an elevation of 15 feet above present grade level will have to be able to function properly in an average environment of at least:

- 70 millivolts per meter over the 600 to 1600 kHz AM band,
- 151 millivolts per meter over the 88 to 107 MHz FM band,
- 131 millivolts per meter over the 60 to 800 MHz television band,
- 109 millivolts per meter over the 150 to 160 MHz land mobile service band,
- 12 millivolts per meter over the 3700 to 4200 MHz South Central Bell Microwave Radio band, and
- 244 millivolts per meter at 5400 MHz, Channel 3 Weather Radar.

(b) The highest signal level measured was 501 millivolts per meter at a frequency of 102.3 MHz (WLRS). This signal therefore represents the worst-case environment which electronic equipment at the 15 foot elevation would be subjected to.

It is noted that the field intensity levels measured are applicable for the specific conditions under which the measurements were made. Under different conditions, i.e., elevation changes, propagation variations, soil moisture content, new construction in area, etc., these intensities could vary considerably. Any shielding offered by materials used in construction will reduce by a corresponding level the field intensities to which equipments in the facility will be exposed. The shielding required is that necessary to reduce the field intensities to a level below the susceptibility threshold of the most sensitive electronic equipment. In fact, an environmental level reduced as much as 10 dB below this susceptibility threshold is recommended.

6. References

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2. J. C. Toler, F. R. Williamson, D. R. Sentz, and G. R. Taylor, "Cardiac Pacemaker Susceptibility to Selected Electromagnetic Environments," Georgia Tech Final Report on Project A-1416-001, Standard Industrial Agreement with Cordis Corporation, Miami, Florida, September 1973.

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4. Federal Communications Commission Rules and Regulations, Volume III, Part 73, September 1972.

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APPENDIX

MATHEMATICAL PREDICTIONS OF FIELD INTENSITY

The electromagnetic field intensity at a specified location due to a remote transmitter is a function of many variables. However, if sufficient knowledge of these variables can be obtained, this field intensity can be statistically predicted using procedures and data given in the Federal Communications Commission (FCC) Rules and Regulations, Volume III, Part 73. If such predictions could be accurately made, the time and expense of site measurements could be greatly reduced if not completely eliminated. Therefore, a limited effort was undertaken to determine the extent to which field intensities at the proposed site for the Data Processing Center could be predicted.

The primary variables capable of influencing field intensity and therefore of concern were as follows:

(a) Topology - hills, valleys, and terrain characteristics that describe the general lay of the land at the test site,

(b) Ground electrical characteristics - Conductivity and dielectric constant of the earth at the test site,

(c) Local siting effects - trees, building structures, power lines, etc.,

(d) Transmitting antenna parameters - Height and direction characteristics,

(e) Transmitter radiated power and frequency,

(f) Separation distance between transmitting antenna and test site, and

(g) Height above the test site average terrain at which field intensity values are desired for frequencies in the FM band and above.

At the onset of the prediction effort it was recognized that detailed information defining some of these variables was incomplete. It was also recognized that, even if knowledge for all of these variables was readily available, predicted field intensities at the site could still vary considerably as a function of climatic conditions. For example, moisture content of the soil at any point in time appreciably affects ground conductivity which, in turn, influences field intensity. In fact, varying climatic conditions often cause major differences in field intensities measured at the same location but at two different points in time.

Information known and/or assumed for the above variables was as follows: (a) ground conductivity[4] of 8 MMHOS/M, (b) ground dielectric constant[4] of 15 esu, (c) transmitter radiated powers and frequencies[5,6], (d) transmitter antenna heights[5,6], (e) separation distances, and (f) the test site was free of trees, buildings, power lines, etc. Since the available data in the FCC Rules and Regulations was applicable only for a 30 foot antenna height, at the test site the predicted field intensities were valid only at this height. No information was available regarding direction characteristics of transmitter antennas.

Using this information, field intensities at the proposed site were prediced for each local AM, FM, and TV station. These predictions are presented in Tables VIII, IX, and X. Over the AM broadcast band, Table VIII shows that the measured and predicted values of field intensity differ at most by 6 dB (a factor of 2). This difference is generally considered an acceptable correlation for the two methods of obtaining field intensity at a test site. This "good" correlation is attributed to the fact that propagation in this frequency range is primarily via ground waves. Therefore, factors which significantly influence propagation through space are of little consequence.

In Tables IX and X, the measured and predicted field intensity values differ by as much as 17 dB (a factor of 7). These differences can be attributed to numerous things; (1) the fact that direction characteristics of the transmitting antennas were not considered, (2) the assumed values for ground conductivity and dielectric constant were probably inaccurate, and (3) the test site was surrounded by numerous tall structures. Also, the predicted field intensity values are applicable to a 30 foot height above the average test site terrain while the measured intensities were obtained at a height of 15 feet. However, this difference in heights is not thought to be a major source of error. Therefore, the 15 foot antenna height for the measured intensities should compare reasonably well with the 30 foot height above average terrain used for the predicted intensities.

Based on the results obtained, it is evident that (1) the predicted field intensity values compared reasonably well only over the AM broadcast range of frequency and (2) unless considerably more information regarding variables capable of influencing field intensity at a given site can be provided, test site measurements will still be required.

TABLE VIII

COMPARISON OF CALCULATED AND MEASURED FIELD INTENSITIES -- AM BROADCAST BAND

Broadcast Station	Measured Field Intensities: Location #1 (dBμV/m)	Measured Field Intensities: Location #2 (dBμV/m)	Calculated Field Intensities: FCC Method (dBμV/m)
WTMT	93	93	88
WAKY	92	91	88
WHAS	92	93	95
WFIA	95	94	93
WAVE	103	101	98
WKLO	108	102	102
WINN	90	90	95
WREY	79	81	83
WLOU	105	105	102
WXVW	93	93	91
WHEL	85	86	88

TABLE IX

COMPARISON OF CALCULATED AND MEASURED FIELD INTENSITIES -- FM BROADCAST BAND

Broadcast Station	Measured Field Intensities		Calculated Field Intensities	
	Location #1 (dBμV/m)	Location #2 (dBμV/m)	FCC Method (dBμV/m)	LOS Method (dBμV/m)
WFPL	101	104	108	108
WFPK	111	110	122	122
WNNS	80	88	71	95
WCSN	86	87	90	100
WLRS	114	113	113	113
WSTM	59	63	63	87
WFIA	105	113	111	111
WVEZ	88	86	94	102

TABLE X

COMPARISON OF CALCULATED AND MEASURED FIELD INTENSITIES -- TELEVISION BROADCAST BAND

Broadcast Station	Measured Field Intensities		Calculated Field Intensities	
	Location #1 (dBμV/m)	Location #2 (dBμV/m)	FCC Method (dBμV/m)	LOS Method (dBμV/m)
CHN. 3/WAVE				
• Video	84	89	94	102
• Audio	80	83	87	95
CHN. 11/WHAS				
• Video	101	94	101	104
• Audio	93	85	94	97
CHN. 15/WKPC				
• Video	104	103	99	107
• Audio	99	96	91	99
CHN. 32/WLKY				
• Video	111	112	113	118
• Audio	101	104	106	111
CHN. 41/WDRB				
• Video	113	106	109	113
• Audio	101	100	99	103

A second method for mathematically determining field intensity at a site was briefly investigated to determine its feasibility as a prediction tool. This method, usually referred to as the Line of Sight (LOS) method, yields worst-case levels of field intensity because it assumes main-beam illumination. It is calculated using the following formula:

$$F.I. = \frac{\sqrt{377\ P_t G_t}}{4\pi d^2}$$

where:
F.I. = Field Intensity in volts per meter,
P_t = Transmitted power in watts,
G_t = Transmitting antenna gain, and
d = Separate distance between the transmitter and test site in meters.

Calculations using this method were made for the FM and TV frequency bands and the results are shown in Tables IX and X, respectively.

As in the case of predictions using the FCC procedures, it appears that field intensity levels predicted in the LOS method are not sufficiently accurate to preclude test site measurements. However, the predicted field intensities will provide an upper bound on the environment possible at a test site of interest.